EFFECTS OF DELTA V AND STEERING WHEEL INTRUSIONS ON AIRBAG PROTECTION OF BRAIN & FACE AND CORPOREAL INJURIES IN FRONTAL MOTOR VEHICLE CRASHES

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MOTOR VEHICLE CRASH STUDY METHODS AND MATERIALS (1,2,3)
265 completed crash reconstruction MVC's were analyzed
rollovers, ejections and pediatric cases were excluded
97 Frontal Non-Airbag (non-AB)
62 Frontal Airbag (AB)
62 Lateral Non-Airbag

GLASGOW COMA SCALE AND SHOCK

The severity of brain injury is estimated in the field or on admission to the hospital by the use of the heuristically validated Glasgow Coma Scale (GCS) (4) based on a scale of 3 (most severe) to 15 (normal). In this study the patients were grouped into mild brain injury (GCS$\geq$13) and severe brain injury (GCS$\leq$12).

Shock is defined as a physiological hemodynamic instability due to circulatory blood volume loss and is associated with a reduced blood pressure and metabolic acidosis. The pressure of low flow shock interacts with a reduced GCS to induce a worse brain injury outcome in terms of a higher mortality or a more significant impairment of brain function in MVC survivors of brain injury (5).

MOTOR VEHICLE CRASH STUDY RESULTS:

FRONTAL CRASHES

In comparing all frontal MVC AB vs. non-AB cases. The AB provided a significant reduction in the incidence of shock and organ system injury of face lacerations, face fractures, spleen and lower extremity fx. In addition, AB protection mitigates the severity of brain injury (higher proportion with GCS>=13, lesser with GCS<=12) and the need for extrication.

FRONTAL CRASHES WITH BRAIN INJURY

In AB vs. non-AB cases where only those patients with brain injury were evaluated. The pattern of organ system injury suggests that in those cases with AB protection significantly reduces brain injury severity and the incidence of face fx. and lower extremity fx. was also lowered.

All Frontal Airbag cases Effect of Delta V (ΔV)

The ΔV is a major causative factor. By stratifying the cases by ΔV at <=48 kph and >48 kph the injury pattern among the total AB population shows continued protection of brain and facial bones regardless of ΔV but, there is a significantly higher incidence of thorax, lung, liver and spleen injury; and upper extremity, lower extremity and pelvic fractures as ΔV increases > 48 kph.

All Frontal non-Airbag Effect of Delta V (ΔV)

As ΔV increases in the non-AB population we note a further increase in the incidence of severe brain injury. However, increasing ΔV also appears to influence the organ system injury pattern by increasing the percentage of visceral injury (lung, liver, spleen) and lower extremity fractures (NS).

Frontal Cases with Brain Injury Level of ΔV

In the group of AB cases with brain injury stratifying for ΔV<=48 and ΔV>48 kph shows that with increased ΔV there is significant increase in thorax, lung, liver and spleen visceral injuries. There was also increased incidence in upper, lower extremity and pelvic fxs that did not quite reach statistical significance. However, the protection from more severe brain injury was largely maintained by AB deployment inspite of the higher mean ΔV.

Frontal nonAB with Brain Injury Effect of ΔV

In the nonAB brain injured group as ΔV increased > 48 kph the incidence of severe brain injury rose from 54% to 70% of all brain injured patients and there was a significant increase in the incidence of hepatic trauma (30%) over that seen at ΔV <=48 kph (4%).

Frontal MVC with Brain Injury AB-ΔV Interaction at low ΔV

In brain injured cases a comparison between the AB and non-AB at ΔV<=48 kph revealed that AB's significantly reduced the brain injury severity (from 54% to 20%) and the associated incidence of shock, face fx., upper extremity fx., lower extremity fx. as well as the need for extrication from MVC.

Frontal with Brain Injury AB-ΔV interaction at high ΔV

In brain injured cases a comparison at ΔV>48 kph demonstrates that the AB continues to protect by significantly reducing brain injury severity (from 70% to 30%), face lac., and face fx. However, in the AB cases at high ΔV there was no reduction in shock and an increase in thorax, lung, liver and spleen injuries, which may suggest that at higher ΔV the AB contributes to the force imparted to the torso while protecting the head.

All Frontal Crashes non-belt AB vs. Belt non-AB

In a comparison between AB protection without seatbelts vs. belting without AB we note AB's significantly reduced the number of face lac., face fx. and lower extremity fx. Although there was slightly higher incidence of all brain injury we note that the severity is remarkablely reduced by the presence of an AB. Of interest among the no-belt AB cases is the (NS) increase incidence of liver injury probably due to absence of belt use.

Frontal Crashes with Brain Injury non-Belt AB vs Belt AB

By focusing on the brain injured patients only in the AB without belt vs. belt non-AB injury cases. AB's without belt compared to belt non-AB reduced brain injury severity. The AB also significantly reduced incidence of lower extremity fx. Though not statistically significant the AB alone appears to protect against shock, face lac. and face fx better than belt use without AB.

All Frontal Crashes belt AB vs. non-Belt non-AB

In the best and worst case scenario comparison between belted AB vs. unbelted nonAB. The combination of BtAB protection significantly reduced brain injury severity and the incidence of shock, face lac., face fx., lung injury and the need for extrication. Although not significant there were minor reductions in incidence of visceral injuries in the BtAB compared to the worst case scenario of no belt non-AB.

Frontal Crashes with Brain Injury belt-AB vs. non-Belt non-AB

Focusing only on the brain injured patients of the best (BtAB) and worst case (noBtnoAB) scenarios shows significant reductions in incidence of brain injury severity by the BtAB combination. Similar incidence reductions were also noted among the organ systems of the BtAB group but, these were not significant.

Airbag Protection in Steering Wheel Intrusion Injury

For the same mean ΔV with comparable magnitudes of intrusion there is a less brain injury severity (GCS=13) with AB cases compared to that found in the non-AB cases (GCS=11).

Airbag Protection in Steering Wheel Contact vs. Intrusion Injury

Comparing brain injury due to the steering wheel contact only vs. brain injury produced by steering wheel intrusion it can be seen.

1) that the magnitude of the ΔV is the major factor producing intrusion and reduced GCS.
2) when there is no intrusion the AB provides more complete GCS protection against contact only injury.

Non-Airbag: Frontal vs. Lateral MVC

In the absence of airbags frontal crashes produced significantly less brain injury but the severity of the brain injuries was not different between frontal and lateral. Frontal crashes had greater face lac. and face fx. more upper and lower extremity fx. but, lateral crashes had a higher incidence of pelvic fx.

FRONTAL AIRBAG VS. LATERAL NON-AIRBAG

Comparing frontal MVC protected by AB with lateral non-AB crashes it can be seen that the frontal crashes had significantly less severe brain injuries (FAB 23% vs. LnoAB 63%) and less shock, lung injury, pelvic fx and less need for extrication.

CONCLUSION

Airbags provide a significant degree of protection against frontal crash induced brain injuries, facial fractures and lacerations. Airbags may also significantly reduce the incidence of lower extremity injuries by preventing submarining.

The effect of airbag protection can be overridden to some extent by marked increases in $\Delta V > 48$ kph. Brain protection is still present though somewhat reduced in effectiveness. But, the incidence of visceral injuries, lower extremity and pelvic fractures is markedly increased by a higher ΔV
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The airbag provides protection against steering wheel intrusion with regard to contact intrusion injuries of the brain and face. It also provides protection against face and head injury due to windshield contacts.

The significantly high level of protection of brain and face injuries provided by the airbag deployment in frontal crashes suggests that there may also be significant protection against those injuries if lateral airbags designed to protect the head were also provided.

Whether a reduction in airbag deployment speed will continue to provide equivalent airbag protection needs to be evaluated by ongoing systematic crash study research.

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